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FLEXURAL BEHAVIOUR OF LIGHT GAUGE COLD FORMED STEEL 'Z' AND 'HAT' SECTIONS WITH AND WITHOUT LIPS

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ABSTRACT

Cold-formed steel has been widely used in modern day construction industry. The property of the cold-formed steel makes it economic and feasible. In this project, an attempt has been made in order to investigate the flexural behavior of light gauge cold formed steel 'Z' and 'HAT' sections with and without lips. The flexural behaviour is evaluated both theoretically and analytically using ANSYS and the results are compared in this study. In the analytical work, four sections were loaded vertically while the lateral deflection was unrestrained to allow flexural buckling. From the results it is evident that at any particular load sections with lips will have less deflection than sections without lips (Z, HAT) and load is taken more by sections with lips than without lips (Z, HAT).

Key words: Cold-Formed Sections, Ansys, Flexural Strength, Deflection.

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1. INTRODUCTION

Cold-formed steel sections are also known as light gauge steel sections. Cold-formed Steel members are being widely used in civil works such as buildings, bridge works, storage racks, drainage works, car bodies, , railway cabins, transmission towers and are used in various equipment's. In Great Britain cold-formed steel members were used in building construction from 1850s. However, light gauge steel members were widely used in buildings in U.S from 1940s. The advantages of cold- formed steel members compared with materials such as timber and concrete were given below. Light weight, High stiffness and strength, Ease fabrication, Easy to install and erect, Economical in Transportation. In the construction

industries structural and non-structural members are created from light gauge steel sheets. Cold-forming is manufacturing the products by forming a material in cold state from a sheet of uniform thickness. There are different methods for cold forming but in the case of structural sections the methods used are folding, press braking and rolling.

The folding process is not suitable for larger length specimens. Press braking is more frequently used when different cross sections are required. Here a section is formed by press braking the sheet between shaped dies to form a required profile shape. Usually each bend is formed separately. Mass production of cold-forming is done in cold rolling. In this process the sheet is continuously feed into rollers to form a desired shape of cross section. For steel structural construction we generally used two kind of steel, one is hot rolled steel and cold formed steel. There are some basic difference between cold formed and hot rolled steel, the main difference will be in their manufacturing at the mill and not with their specification or grade. The mechanical properties such as ductility, yield point and tensile strength of cold-formed steel sections, especially at the edges, will be sometimes different from those of the flat steel plate, sheet before forming. Because cold-forming results in increase in tensile strength, Yield point and also decrease in ductility.

2. SPECIFICATIONS

The physical properties of cold formed steel materials which are used in this project, is calculated by tension coupon test and tabulated in table 1.

Table 1 Property of Cold Formed Steel.

Yield Strength	210 N/mm^2
Modulus of Elasticity, E	2.0x10^5 N/mm^2
Poisson ratio	0.3

The test specimen of Z and HAT sections are shown in Figure 1 to Figure 4.

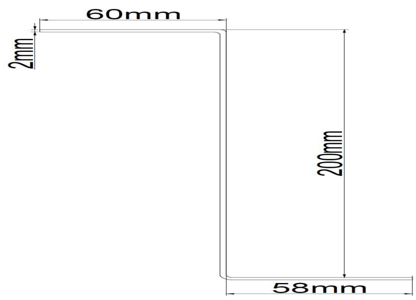

Figure 1 Section properties of 'Z' section without lip

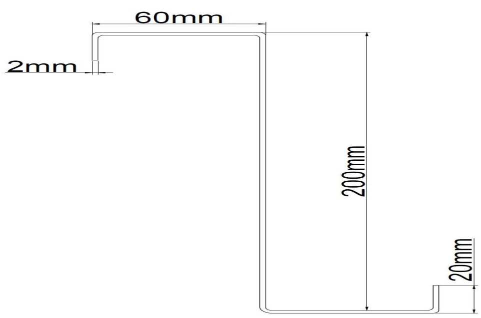

Figure 2 Section properties of 'Z' section with lip

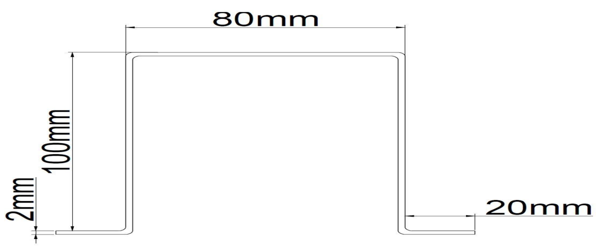

Figure 3 Section properties of 'HAT' section without lip

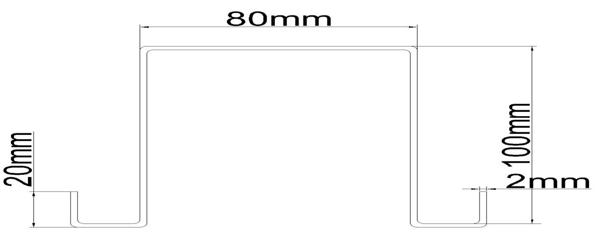

Figure 4 Section properties of 'HAT' section with lip

The specimen details used in this research were shown in Table 2.

Table 2 Specimens details

Specimen(mm)	Dimension(mm)	Length(mm)
Z-section without lips (S-1)	200x60x2	1500
Z-section with lips (S-2)	200x60x20x2	1500
HAT-section without lips (S-3)	100x80x20x2	1500
HAT-section with lips (S-4)	100x80x20x20x2	1500

3. THEORETICAL INVESTIGATION

The present study is carried out to understand the flexural behaviour of cold formed light gauge steel using IS: 801-1975 and IS: 811-1987.

Computation of effective width

The effective width of compression flange is calculated as below

The basic design stress

$f_b = 0.6\ f_y$

Where $f_y = 210$ N/mm^2 $f_b = 0.6 \times 210 = 126$ N/mm^2

For load determination, effective width is given by,

If $(w/t)<(w/t)_{lim}$

W=b

Where, w – flat width of the compression element, t – thickness of the element, b – effective width of the element, f – Basic design stress.

From IS: 801-1975,

$(w/t)_{lim} = 1435/(f)^{1/2}$

To design edge/ lip stiffener

$I_{min} = 1.83t^4((w/t)^2-(281200/F_y))^{1/2} > 9.2t^4$

The required minimum depth of the lip should be

$d_{min} = 2.8((w/t)^2 - 281200/F_y))^{1/6}$

From the codal provisions the moment carrying capacity and load carrying capacity is calculated and listed in the Table 3.

Table 3 Theoretical values using IS 801-1975 and IS 811-1987

Section	Moment Carrying Capacity(KN-m)	Load Carrying Capacity(KN)
S-1	4.54	18.16
S-2	5.04	20.16
S-3	1.87	7.5
S-4	2.42	9.7

4. FINITE ELEMENT MODELING

The finite element method is a numerical analysis technique for obtaining approximate solutions to wide variety of Engineering problems. Most of the engineering problems today make it necessary to obtain approximate numerical solution to problems rather than exact closed form solutions. The basic concept behind in the finite number of elements having finite dimensions and reducing the structure having infinite degrees of freedom to finite degrees of freedom. Then the original structure is the assemblage of these elements connected at a finite element analysis an advanced software of ANSYS R.15 was used. The elastic properties of material were assigned to create a model cold formed steel Z and HAT section with and without lips. The value of Young’s modulus, ‘E’ is taken as 2.0×10^5 N/mm^2. The Poisson’s ratio is taken as 0.3.

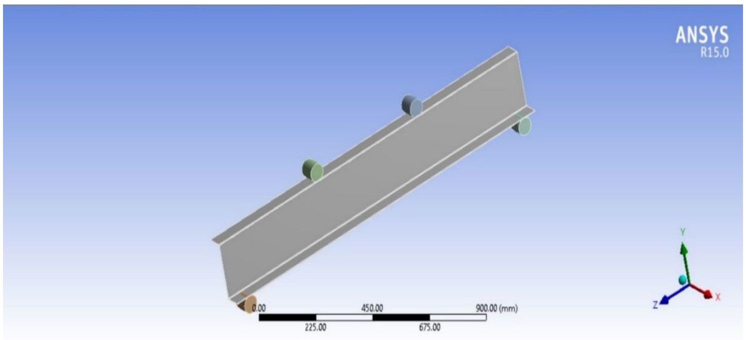

Figure 5 ‘Z’ section without lip

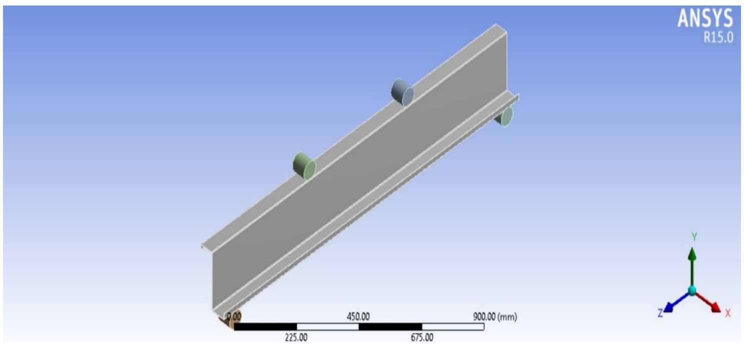

Figure 6 ‘Z’ section with lip

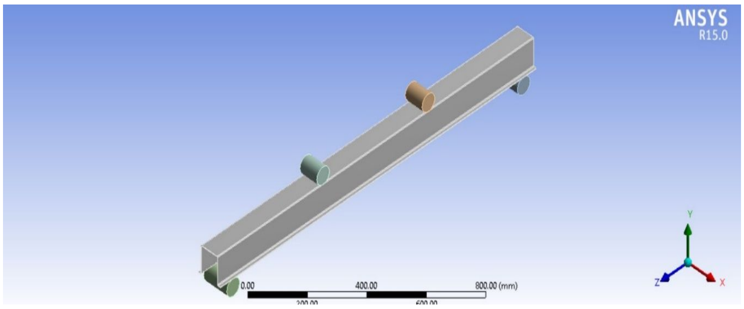

Figure 7 'HAT' section without lip

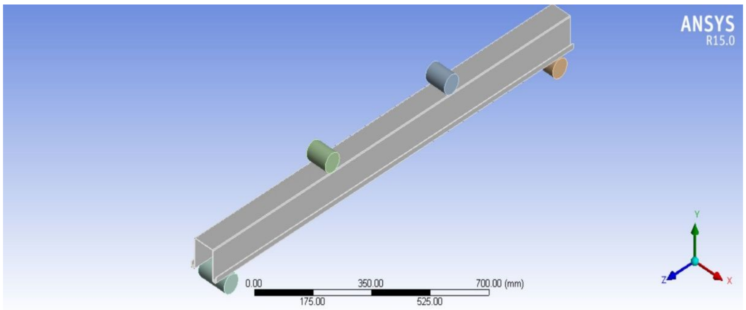

Figure 8'HAT' section with lip

5. RESULTS AND DISCUSSIONS

The analysis is carried out using ANSYS. The results of the models are discussed in terms of deflection. The analytical results of Light gauge cold formed 'Z' and 'HAT' sections are discussed and their results are as analysed analytically.

The deformed shapes for the various sections are shown in Figure 9 to Figure 12.

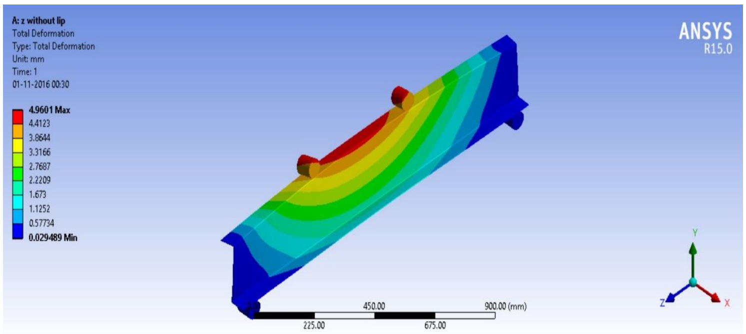

Figure 9 Deflection of 'Z' section without lips

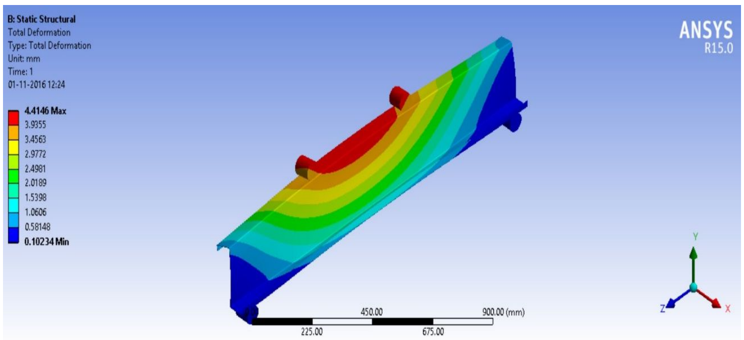

Figure 10 Deflection of 'Z' section with lips

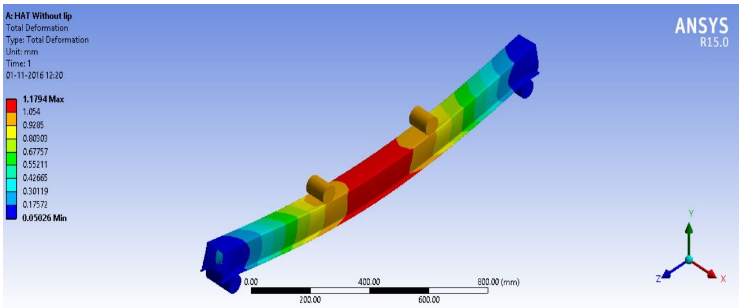

Figure 11 Deflection of ‘HAT’ section without lips

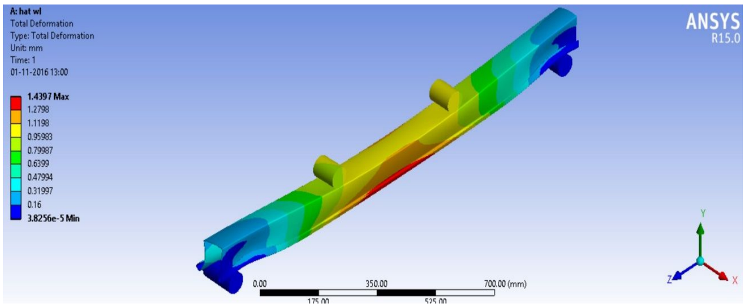

Figure 12 Deflection of ‘HAT’ section with lips

The maximum deflection values are tabulated in Table 4 and it was found that the maximum deflection is 4.96 mm for Z-section without lips and the maximum deflection for HAT section with lips. Hence the lips plays an important role in load carrying capacity and deflection.

The LOAD VS DEFLECTION graph in Fig 13 for Z section with and without lips is plotted and it clearly shows that at any particular load Sections with lips will have less deflection than that of sections without lips and also shows that Z section with lip will take more load than Z section without lips.

Table 4 Maximum deflection values

Section	Maximum Deflection(mm)
S-1	4.96
S-2	4.41
S-3	1.54
S-4	1.47

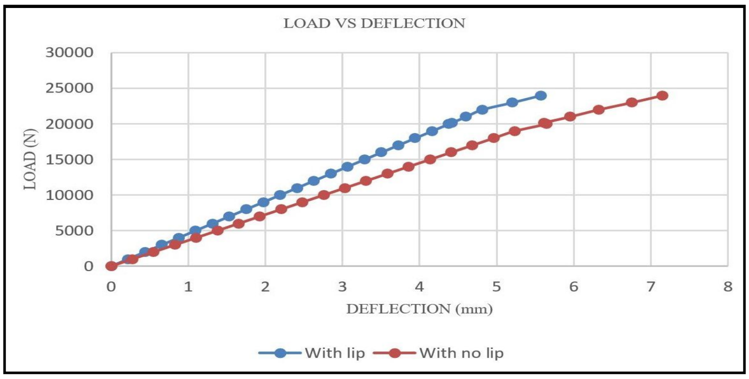

Figure 13 Load vs deflection for Z Section with and without lips

The LOAD VS DEFLECTION graph in Fig 14 for HAT section with and without lips is plotted and it clearly shows that at any particular load sections with lips will have less deflection than that of sections without lips and also shows that HAT section with lip will take more load than HAT section without lips.

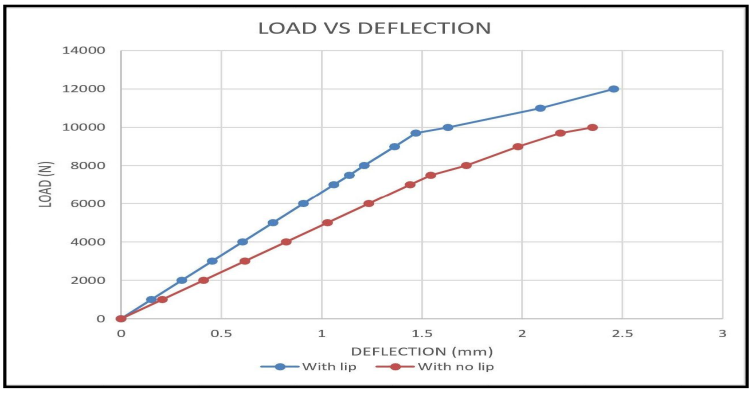

Figure 14 Load vs deflection for HAT Section with and without lips

6. CONCLUSION

Analytical and Theoretical investigations were carried out to make a comparative study on the flexural behaviour of Z and HAT sections with and without lips and following conclusions were drawn.

- The ultimate load carrying capacity of cold formed Z section with lip was 11% higher than that of cold formed Z section without lip.
- The ultimate load carrying capacity of cold formed HAT section with lip was 29% higher than that of cold formed HAT section without lip.
- The ultimate deflection of cold formed Z section with lip was 4.416 mm and the ultimate deflection of cold formed Z section without lip was 4.96 mm.
- The ultimate deflection of cold formed HAT section with lip was 1.4705 mm and the ultimate deflection of cold formed HAT section without lip was 1.5438 mm.
- The lips provided in the section enhances the load carrying capacity and reduces the deflection of the member

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